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Using Google Earth Engine to assess the impacts of climate change on land use in the Gheris watershed, Morocco

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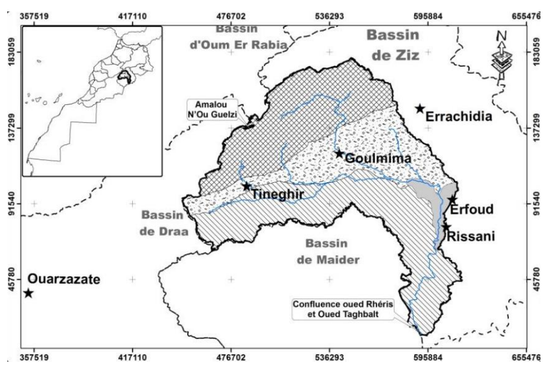
INTRODUCTION & AIM

The climate change that the Earth has experienced in recent decades is mainly manifested by rainfall deficits and more frequent and intense heat waves. In Morocco, these weather events have a direct impact on water resources, agriculture, and food security, particularly in already vulnerable regions such as the Ghéris watershed, which is the subject of this study. To mitigate the impacts of these weather events, we must first better understand their spatial and temporal variability and their impact on ecosystem dynamics. With this in mind, the indicators obtained by applying certain machine learning algorithms and calculating spectral indices are perfectly suited to identifying changes recorded in this region between 1990 and 2024.

STUDY AREA

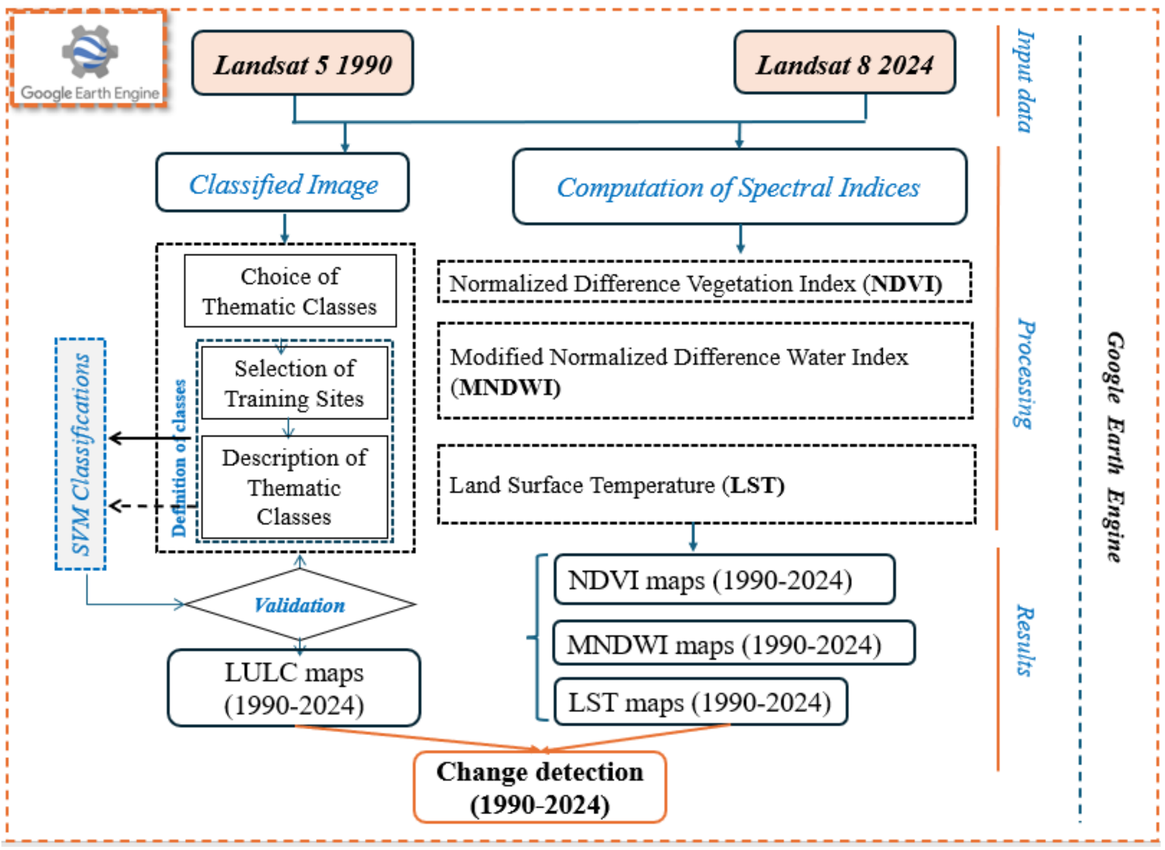
The Ghéris watershed, the subject of this study, is located in the far southeast of Morocco. It extends from northwest to southeast, between 30°40'N and 32°00'N and between 4°20'W and 6°00'W, covering an area of 17,500 ha. Its arid to semi-desert climate is characterized by rainfall patterns that vary greatly from year to year, reflecting the irregularity of precipitation, and by temperatures that exceed 40°C in summer. The objective of this study is, on the one hand, to qualify and quantify the effects of climate change on land use in the Ghéris watershed.



Location of the study area.

METHOD

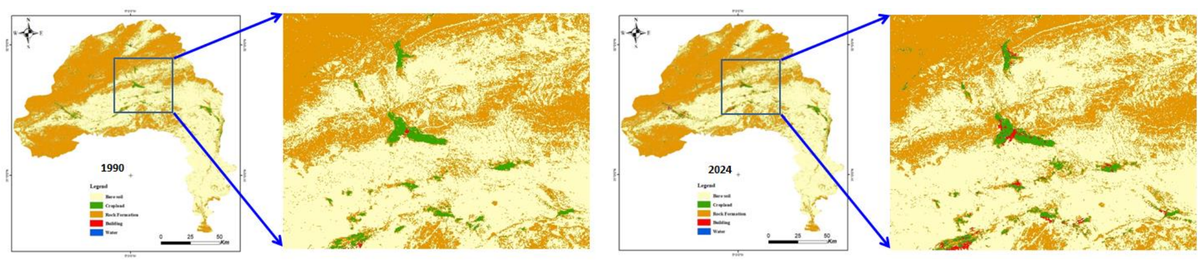
In order to identify and monitor the impacts of climate change on the Ghéris watershed, geospatial data from 1990 and 2024 were used from the Google Earth Engine (GEE) platform. This data underwent a series of digital processing and multispectral remote sensing image analysis, including supervised classifications (support vector machine (SVM) and Random Forest (RF)) and the calculation of spectral indices (Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI)). The flowchart below shows the different stages of the methodology adopted.



RESULTS & DISCUSSION

Land use and land cover (LULC)

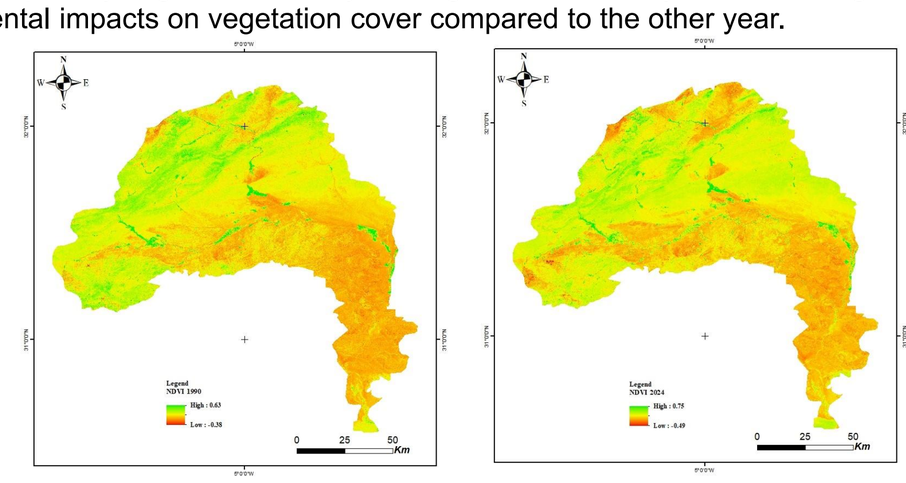
The application of SVM and RF machine learning classification algorithms made it possible to generate images of the main land use and land cover (LULC) units.



Comparative analysis of the two images reveals a significant expansion of bare ground and built-up areas, correlated with a drastic decline in vegetation and water areas.

The Normalized Difference Vegetation Index (NDVI)

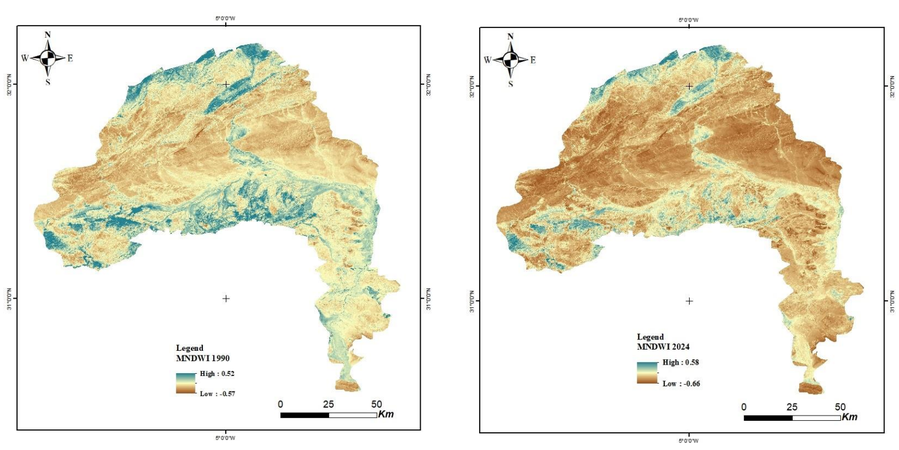
Calculating the NDVI using the formula NDVI = (PIR –R)/ (PIR +R) for both years made it possible to quantify vegetation density and vigor over the two years, revealing the environmental impacts on vegetation cover compared to the other year.



The compared NDVI images show a significant decline in vegetation cover.

The Normalized Difference Water Index (NDWI)

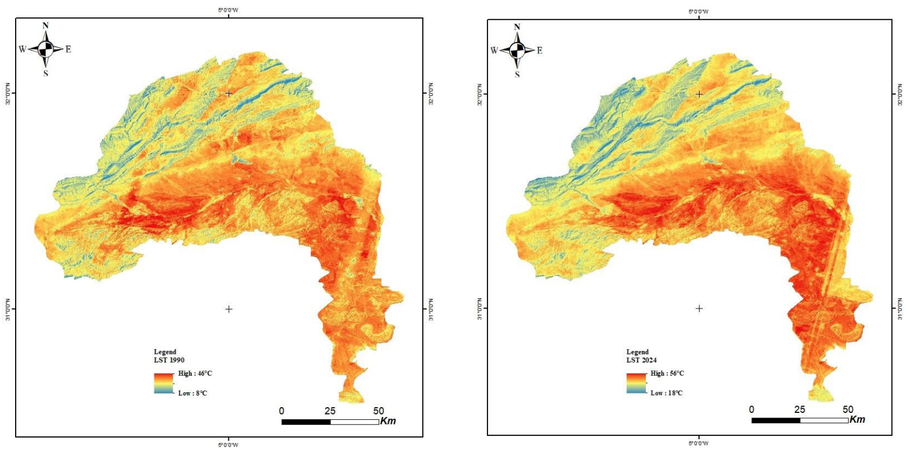
Calculated using the formula NDWI = (green band – PIR) / (green band + PIR), this index is used to highlight the presence and spatial distribution of water bodies (surface water bodies) and water content or moisture in vegetation and soil.



A comparative analysis of the two images revealed a significant decrease in wetlands and water bodies within the Ghéris watershed.

Land Surface Temperature (LST)

LST extraction, used to monitor spatial and temporal variations in land temperature, relies primarily on thermal infrared bands.



Cross-referencing data from the two LST maps reveals a temporal dynamic in spatial occupation, illustrated by the expansion of warm areas (in red) at the expense of cold areas (in blue).

CONCLUSION

Spatial analysis of temporal images generated for the years 1990 and 2024 shows that the Ghéris watershed is mainly composed of bare soil and rock formations, and that vegetation cover and water surfaces are mainly concentrated and located along the river. A diachronic comparative study of the various spectral index calculations (NDVI, NDWI) and supervised classifications of temporal images (LULC and LST) highlighted the impact of climate change, marked mainly by warming since 1990, on water resources in this region, which has had a significant impact on local agriculture.

FUTURE WORK

In view of this study, we will map and quantitatively and qualitatively assess erosion and sand displacement across the Ghéris watershed.